Claims

1. A longitudinal grating having an aperiodic structure, wherein the grating has a selected response characteristic and any repeated unit cell in the structure is significantly longer than a characteristic length associated with the selected response characteristic.

2. A grating as claimed in claim 1, in which the structure comprises discrete grating elements of at least two different kinds.

A1) 3. A grating as claimed in claim 2, which comprises 5 or more grating elements.

4. A grating as claimed in claim 3, which comprises 20 or more grating elements.

5. A grating as claimed in any preceding claim, comprising material which has no, or a negligible, real component or no, or a negligible, imaginary component.

6. A grating as claimed in any preceding claim, in which the selected response characteristic is a spectral amplitude response and the characteristic length is a spectral amplitude cut-off wavelength.

7. A grating as claimed in claim 6, in which the spectral amplitude response includes at least one band gap.

8. A grating as claimed in claim 7, in which the spectral amplitude response includes at least two band gaps.

9. A grating as claimed in claim 7 or 8, in which the band gap is a photonic band gap.

10. A grating as claimed in claim 6, having a low-pass filter spectral amplitude response.

11. A grating as claimed in claim 6, having a band-pass filter spectral amplitude response.

12. A grating as claimed in claim 6, having a notch filter spectral amplitude response.

13. A grating as claimed in claim 6, having a high-pass filter spectral amplitude response.

14. A grating as claimed in claim 6, in which the spectral amplitude response comprises an apodised band-pass filter.

15. A grating as claimed in claim 6, in which the spectral amplitude response comprises a passband-flattened band-pass filter.

16. A grating as claimed in claim 6, in which the spectral amplitude response comprises a comb-like filter.

17. A grating as claimed in claim 6, in which the spectral amplitude response comprises a regimented band-pass filter.

18. A grating as claimed in claim 6, in which the spectral amplitude response comprises a non-uniform response segmented band-pass filter.

A3 19. A grating as claimed in any preceding claim, having a spectral phase response which is linear.

20. A grating as claimed in any preceding claim, having a spectral phase response which is nonlinear.

21. A grating as claimed in any preceding claim which is suitable for phase compensation.

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22. A grating as claimed in any preceding claim, which is suitable for single-frequency dispersion compensation.

23. A grating as claimed in any preceding claim, which is suitable for a multiple-frequency dispersion compensation.

24. A grating as claimed in claim 6, in which the spectral amplitude response comprises a combination of the response characteristics claimed in any of claims 6 to 23.

25. A grating as claimed in any of claims 1 to 24, in which the aperiodic grating structure is 2-dimensional.

26. A grating as claimed in any of claims 1 to 25 in which the aperiodic grating structure is 3-dimensional.

27. A filter comprising a grating as claimed in any of claims claim 1 to 26.

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28. A dielectric stack, comprising a grating as claimed in any of claims 1 to 26.

29. A dielectric stack as claimed in claim 28, for use at a specified wavelength, comprising layers at least one of which is of an optical thickness which is not an integer multiple of one quarter of the specified wavelength.

A4 30. A dielectric stack as claimed in claims 28 or 29, comprising two kinds of layers differing in refractive index.

31. A dielectric stack as claimed in claim 28 or 29, which comprises layers, at least three of which have refractive indices which are different from each other.

32. An optical fibre Bragg-grating, comprising a grating as claimed in any of claims 1 to 26.

33. An optical fibre Bragg-grating as claimed in claim 32, which comprises a structure of two different refractive indices.

34. An optical fibre Bragg-grating as claimed in claim 32, in which the fibre Bragg-grating comprises a structure including at least three points having different refractive indices from each other.

45 35. A waveguide structure comprising a grating as claimed in any of claims 1 to 26.

36. A waveguide structure as claimed in claim 35, comprising a ribbed waveguide structure.

37. A waveguide structure as claimed in claim 36, in which the ribbed waveguide structure comprises two kinds of regions differing in effective refractive indices.

38. A waveguide structure as claimed in claim 36, in which the ribbed waveguide structure comprises at least three kinds of regions each having a different effective refractive indices.

39. A waveguide structure as claimed in claim 35, which is a doped waveguide structure.

40. A waveguide structure as claimed in any of claims 35 to 39, which is a dynamic and/or reconfigurable structure, wherein the grating is arranged so that the magnitude of the relevant parameter may be altered at at least one point in the grating.

41. A waveguide structure as claimed in claim 40 in which the reconfiguration is achieved using a thermo-optic effect.

42. A waveguide structure as claimed in claim 40 in which the reconfiguration is achieved using an electro-optic effect.

43. A waveguide structure as claimed in claim 41 or 42, in which the effect is effected by inter-digitated electrodes.

44. A waveguide structure as claimed in claim 41 or 42, in which the effect is effected by a comb-like electrode.

45. A waveguide according to any of claims 35 to 44, in which the grating is along the length of the waveguide.

46. A waveguide according to any of claims 35 to 45, in which the grating is within the waveguiding region.

~~47. A waveguide structure according to any of claims 35 to 46, in which the waveguide is any of the following: an optical fibre, a microwave strip line, a silica on silicon planar lightwave circuit (PLC), a silicon on silica PLC, a semiconductor amplifier, a semiconductor laser.~~

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~~48. A grating as claimed in any of claims 1 to 26, in which structure is in the material permittivity.~~

~~49. A grating as claimed in claim 48, in which structure is in the refractive index.~~

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~~50. A grating as claimed in any of claims 1 to 26, in which structure is in the material permeability.~~

~~51. A grating as claimed in any of claims 1 to 26, in which structure is in the a magnetic property.~~

~~52. A grating as claimed in claim 51 in which the magnetic property is the orientation and/or strength of a magnetic dipole.~~

A9 53. An aperiodically-poled non-linear material, comprising a grating as claimed in any of claims 1 to 26, which is employed to quasi-phase-match light at two or more wavelengths.

54. An aperiodically-poled non-linear material, comprising a grating as claimed in any of claims 1 to 26, which is employed to suppress light at one or more wavelength.

55. A non-linear optical loop mirror including a non-linear material as claimed in claim 53 or 54.

56. A non-linear optical loop mirror as claimed in claim 55, further comprising an aperiodically poled semiconductor optical amplifier.

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A10 57. A non-linear optical loop mirror including a grating according to any of claims 1 to 26.

58. A non-linear optical loop mirror according to claim 57, in which the grating comprises an aperiodically-poled semiconductor optical amplifier.

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A11 59. A Mach-Zehnder interferometer including a grating according to any of claims 1 to 26.

60. B A Mach-Zehnder interferometer as claimed in claim 59, including such a grating in each of its arms.

A12 61. A Mach-Zehnder interferometer as claimed in claim 59, including an aperiodically-poled non-linear material as claimed in claim 53 or 54.

62. A Mach-Zehnder interferometer as claimed in claim 59, including a waveguide structure as claimed in any of claims 35 to 47.

63. A Mach-Zehnder interferometer as claimed in any of claims 59 to 62, in which the grating is written onto an integrated-optic waveguide.

64. A grating-assisted coupler including a grating according to any of claims 1 to 26.

65. A grating-assisted coupler as claimed in claim 64or claim 65, which is bidirectional.

66. A grating-assisted coupler as claimed in claim 65, which is programmable.

A13> 67. A grating-assisted coupler as claimed in any of claims 64 to 66, including an aperiodically-poled non-linear material as claimed in claims 53 or 54.

68. A laser, including a grating according to any of claims 1 to 26.

69. A laser according to claim 68, in which the grating is in the laser cavity.

70. A laser according to claim 68 in which the grating is comprised in a wavelength-selective mirror.

71. A laser according to claim 70, in which the mirror allows the laser to lase at multiple wavelengths.

A14> 72. A laser according to any of claims 68 to 71, which is pulsed.

73. A laser according to any of claims 68 to 72, which can be modelocked.

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74. A laser according to any of claims 68 to 73, which is a ring laser.

75. A laser according to any of claims 68 to 74, which is a semiconductor laser.

76. A laser according to claim 75 having a DBR structure.

77. A laser according to claim 75, having a DFB structure.

78. A laser according to claim 75, having VCSEL structrue.

B15 79. A Fabry-Perot cavity, comprising at least one end mirror comprising a grating according to any of claims 1 to 26.

80. A Raman amplifier, comprising a Fabry-Perot cavity according to claim 79.

81. A Raman laser, comprising a Fabry-Perot cavity according to claim 79.

A16 82. A material including a grating as claimed in any of claims 1 to 26, in which the grating modifies an electronic bandgap structure.

83. A material including a grating as claimed in any of claims 1 to 26, in which electronic potential has a variation controlling the selected response characteristic.

84. A material as claimed in claim 83, in which the electrical potential comprises classical scatterers.

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85. A material as claimed in claim 83, in which the electrical potential comprises quantum scatterers.

A17 86. A material as claimed in claim 84 or claim 85, in which the scatterers are positioned at the vertices of a lattice or superlattice.

87. A material as claimed in claim 86, in which the superlattice is an electronic superlattice structure.

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88. A material as claimed in claim 86, in which the superlattice is a superconducting superlattice.

89. A material as claimed in any of claims 82 to 88, in which the selected response characteristic is a band minimum.

90. A material as claimed in any of claims 82 to 88, in which the selected response characteristic is an effective mass.

91. A material as claimed in any of claims 82 to 88, in which the selected response characteristic is a thermal conductivity.

92. A material as claimed in any of claims 82 to 88, in which the selected response characteristic is a dielectric permittivity.

93. A material as claimed in any of claims 82 to 88, in which the selected response characteristic is a conductivity.

94. A material as claimed in any of claims 82 to 88, in which the selected response characteristic is a magnetic permeability.

95. A material as claimed in any of claims 82 to 94, which is a superconducting material.

96. A grating as claimed in any of claims 1 to 26, which is in or on a nonlinear medium and which enhances a nonlinear effect.

97. A grating as claimed in any of claims 1 to 26, which is in or on a nonlinear medium and in which the selected response characteristic is phase matching between at least two wavelengths and the characteristic length is an optical path length as measured in air, of $2\pi/\delta\beta$ where $\delta\beta$ is the difference between the propagation constant of two of the phase matched wavelengths.

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98. Use of a grating according to claim 96 or claim 97, in any of the following applications: wavelength conversion, signal re-timing, signal regeneration, parametric amplification, applications involving second- and third-order nonlinear effects (for example, second- and third-harmonic generation or the Kerr effect), or parametric oscillators.

99. A method of making a longitudinal grating comprising: selecting a response characteristic and using an optimisation algorithm to determine a grating arrangement which closely has the selected response characteristic, wherein the grating

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is aperiodic and wherein any repeated unit cell in the structure of the grating is significantly longer than a characteristic length associated with the selected response characteristic.

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100. A method according to claim 99, in which the grating arrangement is varied during optimisation.

A15 101. A method as claimed in claim 99 or 100, in which the elements of the grating are directly and individually varied.

102. A method according to any one of claim9 99 to 101, in which the response characteristic of the grating is taken during optimisation to be approximately, or is derived from, the Fourier Transform of the grating arrangement during optimisation.

103. A method according to claim 102 wherein a cost function is calculated from the selected response characteristic and the Fourier Transform or a function derived therefrom.

A16 104. A method according to any of claims 99 to 103, in which the Fourier Transform of the grating arrangement is evaluated

during optimisation to see if, or how, it differs from the selected response characteristic.

105. A method as claimed in any of claims 99 to 104, in which the optimisation algorithm is simulated annealing.

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106. A method as claimed in any of claims 99 to 105, in which the optimisation algorithm is error-diffusion.

107. A longitudinal grating made using a method according to any of claims 99 to 106.

108. A longitudinal grating which could be made using a method according to any of claims 99 to 106.

109. A longitudinal grating which is aperiodic, comprising a set of concatenated, repeated base cells, at least some of which differ slightly from each other.

110. A longitudinal grating, which has a shortest period which is larger than the period of a regular binary grating which has marks and spaces of the same length as the longest constant region in the longitudinal grating.

~~111. A longitudinal grating as claimed in claim 110, which is aperiodic.~~

A21 ~~112. A longitudinal grating, comprising a plurality of concatenated gratings as claimed in any of claims 1 to 26, 48 to 52, 96 or 97 or 107 or 111.~~

~~113. A grating as claimed in claim 112, in which at least some of the aperiodic structures are identical to each other.~~

~~114. A grating as claimed in claim 113, in which all of the aperiodic structures are identical to each other.~~

~~115. A grating as claimed in claim 1 in which the structure is programmable to switch between a plurality of selected response characteristics.~~

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